

Illustrative Teaching Case

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Patient With Severe Moyamoya Disease Who Presents With Acute Cortical Blindness

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Case Description

A previously healthy 16-year-old girl presented to a local emergency room with intense headache, severe nausea, and vision loss. The week before, she had intermittent headaches and nonspecific visual changes that resolved with acetaminophen or NSAIDs and rest. On admission to the hospital, she was found to be extremely hypertensive and had bilateral occipital hypodensities consistent with infarcts on noncontrast computed tomography.

On transfer to the regional pediatric hospital, she had severe vision loss (light perception only), and magnetic resonance imaging showed bilateral infarctions, especially affecting the posterior circulation and occipital lobes (Figure 1). Magnetic resonance perfusion revealed severe bilateral hemispheric hypoperfusion, and magnetic resonance imaging fluid-attenuated inversion-recovery sequence demonstrated linear hyperdensities along sulci—the ivy sign often seen in moyamoya. Cerebral angiography revealed complete occlusion of the bilateral internal carotid arteries distal to the anterior choroidal arteries with dense moyamoya collaterals and extreme attenuation of the posterior cerebral artery circulation, also with moyamoya collaterals (Figure 2). Biochemical, hemostatic, and genetic evaluations were normal, with the exception of a significantly elevated D-dimer level (1850 ng/mL; normal range: 0–543 ng/μL). Apart from her mother experiencing a deep venous thrombosis during pregnancy, the patient's family history was unremarkable for coagulopathies.

The patient was admitted to the pediatric intensive care unit, where she was started on aspirin. Deterioration in her neurological examination coincided with a relative decrease in blood pressure. Her neurological examination improved with pressors, which were eventually weaned. The patient remained on daily aspirin and had no subsequent strokes, but her cortical blindness persisted. The patient was discharged home with follow-up for surgical planning.

Several weeks after the patient's initial stroke, her neuro-ophthalmologic testing remained notable for light-only perception in both eyes. Both pupils were 4 mm and reactive on

examination. Her ocular alignment was normal and without nystagmus. Slit-lamp examination was unremarkable, and fundal examination revealed healthy optic nerves bilaterally and normal macular response. The patient was diagnosed with cortical vision loss secondary to occipital stroke.

After allowing time for her condition to stabilize, the patient underwent staged bilateral craniotomies for pial synangiosis surgery for indirect revascularization, with the goal of protecting healthy cerebral hemispheres that were at risk for infarction. Her baseline cortical vision loss persisted postoperatively, but no further neurological issues developed.

A 1-year follow-up angiogram confirmed extensive revascularization of the bilateral middle cerebral artery regions, with additional bilateral supply to the anterior cerebral artery territories from the synangioses and collaterals of the ophthalmic arteries.

Discussion

We report a patient with moyamoya disease (MMD) who experienced occipital infarctions resulting in cortical blindness. MMD is a rare progressive occlusive cerebrovascular condition characterized by compensatory collateral circulation resembling a puff of smoke (moyamoya in Japanese) on cerebral angiography. It presents in both pediatric and adult populations, often causing stroke or hemorrhage. To date, its pathogenesis has not been fully characterized. MMD is thought to exhibit some degree of familial inheritance, with an estimated 15% of Japanese MMD patients having an affected family member. In those cases, mutation of *RNF213* encodes a defective E3 ubiquitin ligase involved in angiogenesis. Environmental triggers may factor significantly into the expression of this mutation, as genetically identical twins may be affected differently.¹ Whereas moyamoya disease is idiopathic, moyamoya syndrome refers to moyamoya vasculopathy associated with other conditions, such as neurofibromatosis type 1, sickle cell disease, radiation, and Down syndrome. Its treatment is analogous to that of MMD.

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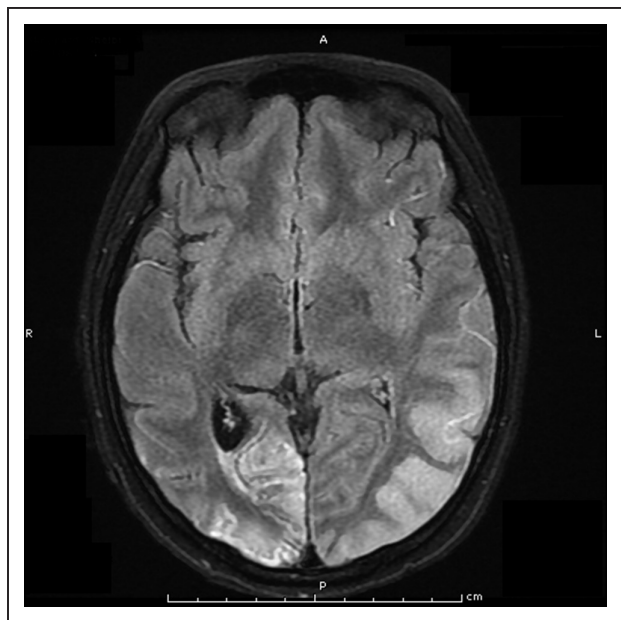


Figure 1. Axial T2 magnetic resonance imaging with bilateral fluid-attenuated inversion-recovery changes revealing infarctions of the right posterior temporal and occipital lobes and of the left parietal, occipital, and posterior temporal lobes. In addition, there were small chronic white matter infarcts in the bifrontal middle cerebral artery–anterior cerebral artery watershed territories (not pictured).

Clinical Manifestations

The clinical manifestations of MMD are consistent with those of cerebral ischemia or intracranial hemorrhage. Therefore, signs of MMD vary with the nature (ischemic versus hemorrhagic) and location of the stroke. Among pediatric patients with MMD, transient ischemic attacks and ischemic strokes are more common, whereas hemorrhage occurs more commonly in adults. The pathology generally affects the anterior circulation of the brain with stenosis of the internal carotid artery near its apex, proximal anterior cerebral arteries, and proximal middle cerebral arteries.¹ Although less common, the posterior circulation may also be affected.

Patients with MMD who initially present with anterior circulation involvement may additionally proceed to exhibit posterior circulation involvement as well.² Anterior circulation ischemia can present with headaches, motor weakness, and aphasia, whereas posterior circulation ischemia may present with headaches and visual symptoms.^{2,3} Hishikawa et al⁴ examined the difference in posterior circulation involvement between adults and pediatric patients with MMD. They found that pediatric MMD patients with posterior circulation involvement (26%) had less advanced internal carotid artery lesions than adult patients with posterior circulation involvement. The group reported a significantly higher rate of infarction in pediatric and adult patients with posterior circulation involvement than those without posterior circulation involvement.

Although there have been previously reported cases of pediatric moyamoya patients presenting with ocular manifestations, the cases were often attributable to direct ocular disease and retinal artery occlusion.⁵ Sudden cortical blindness from an occipital stroke is rare. There have been other

reported cases of complete cortical blindness, but they were all in adults and often had precipitating symptoms before the onset of full blindness.⁶

The present case is a rare presentation of isolated MMD presenting with acute cortical blindness in a pediatric patient. Although the majority of MMD patients present with symptoms related to anterior circulation ischemia, this patient presented with acute posterior circulation infarction without any significant initial anterior circulation deficits. This case demonstrates the importance of the practitioner's ability to recognize the atypical signs and symptoms of this disease. Although rare, MMD should be considered in the differential diagnosis of acute cortical vision loss.

Diagnosing Moyamoya

Diagnosis of MMD requires evidence of narrowing of the distal internal carotid arteries, which extends to the proximal middle cerebral arteries and anterior cerebral arteries, along with collateral circulation formation at the base of the brain (Figure 1).¹ Cerebral angiography, the gold standard of MMD diagnosis, should confirm these findings.⁷

Treatment Options

Class I recommendations for MMD treatment emphasize revascularization surgeries, which can be effective in preventing progressive MMD symptoms and are generally categorized as direct or indirect procedures.⁸ Direct approaches to surgical revascularization involve anastomosis of the superficial temporal artery to a cortical artery. Indirect revascularization procedures vary in nature but generally call for placement of the dura, temporalis muscle, or superficial temporal artery onto the surface of the brain to stimulate subsequent blood vessel growth. Revascularization surgery offers promising results, conferring up to a 96% probability of remaining stroke free for 5 years postoperatively.¹ Indirect approaches are performed more often in children because their small vasculature renders direct anastomosis challenging.¹ Although no definitive consensus in the literature has been reached comparing the effectiveness of either surgical approach, a recent meta-analysis by Macyszyn et al⁹ concluded that indirect revascularization surgeries are associated with superior long-term results compared with direct procedures in both children and adults.

This patient underwent pial synangiosis surgery, which is a type of indirect revascularization surgery and a variant of encephaloduroarteriosynangiosis. In pial synangiosis surgery, the superficial temporal artery, which is normally extracranial, is isolated while being kept in continuity. A craniotomy is performed, the dura and arachnoid are opened, and the superficial temporal artery is secured to the pia overlying the surface of the brain. After a few months, new blood vessels grow into the brain to provide better vascular supply. A study by Scott et al¹⁰ found that $\approx 75\%$ of children with MMD went on to lead independent and normal lives at long-term follow-up after undergoing this revascularization procedure.

Medical therapies alone are not recommended, although class II recommendations suggest the administration of antiplatelet agents like aspirin, as tolerated, for additional stroke prophylaxis. Class III evidence, meanwhile, discourages

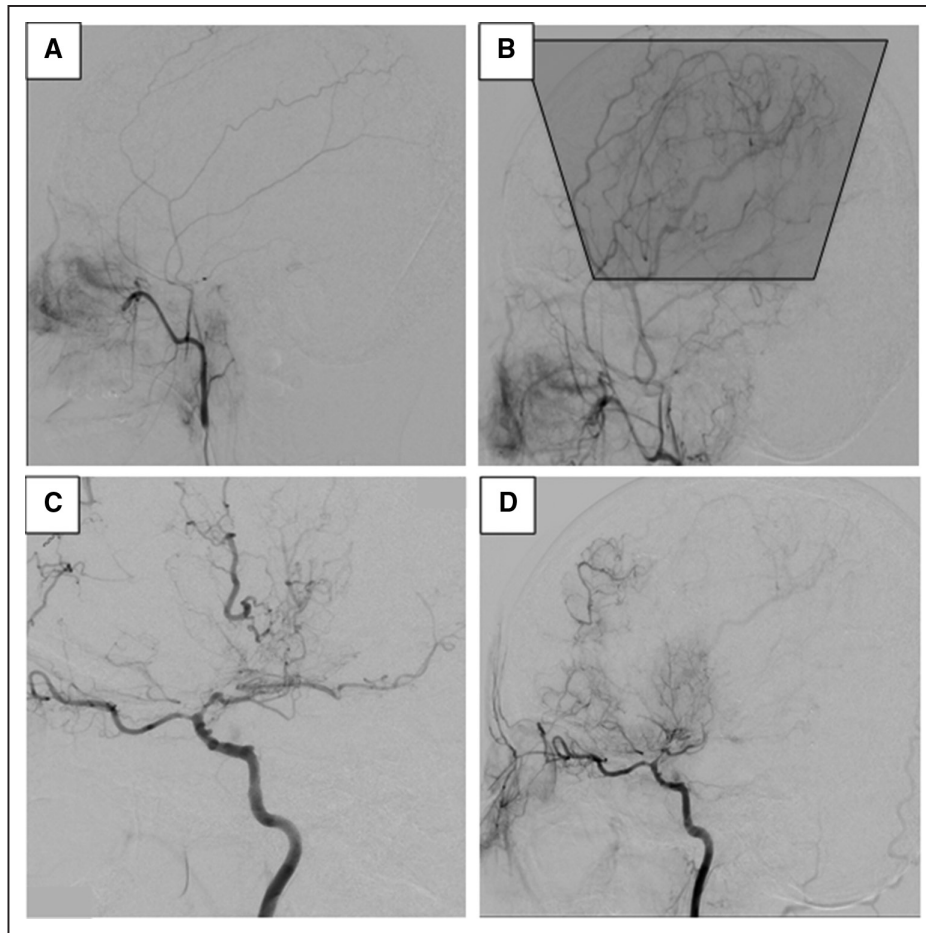


Figure 2. Angiographic images (lateral views) showing effects of surgical treatment with pial synangiosis. **A** and **B**, Right external carotid artery injections, preoperatively (**A**) and at 1-y follow-up (**B**). There is extensive revascularization in the right middle cerebral artery territory and superior part of the right anterior cerebral artery territory (boxed area). The superficial temporal artery and middle meningeal artery are hypertrophied on the follow-up angiogram, indicating increased blood flow. **C** and **D**, Right internal carotid artery (ICA) injections, preoperatively (**C**) and at 1-y follow-up (**D**), which show occlusion of the ICA distal to the anterior choroidal artery and progressive moyamoya collaterals during that time.

administration of anticoagulants because these could elevate the risk of subsequent hemorrhage.⁸ Further prophylactic measures include good hydration and the avoidance of hyperventilation, in order to decrease the likelihood of hypovolemia or vasoconstriction.

TAKE-HOME POINTS

- Moyamoya disease (MMD) is a rare condition but important cause of stroke in children.
- MMD usually affects the anterior cerebral circulation, but the posterior cerebral circulation can be affected as well.
- MMD may cause occipital stroke in children and thus should be considered in the differential diagnosis of acute vision loss.
- Direct and indirect surgical revascularization surgeries can be used to effectively revascularize areas of brain affected by MMD and have been shown to reduce the risk of stroke in patients with MMD.¹

Disclosures

None.

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KEY WORDS: arteries ■ cerebral hemorrhage ■ encephaloduroarteriosynangiosis ■ moyamoya disease ■ neurosurgery ■ pial synangiosis ■ stroke